

ADULT MOSQUITO CONTROL INTERVENTION PARAMETERS

Scientific Data to Support Effectiveness of Spraying

**Working Group One
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GOALS:

- To produce a compendium of published articles that describe the efficacy and limitations of aerial and ground spraying. (Page 5-25).
- To produce recommendations on the efficacy and limitations of both ground and aerial spraying. (Pages 3-4).
- To produce a summary on the effectiveness of Massachusetts 1990 Eastern Equine Encephalitis Intervention. (Pages 26-32).

RECOMMENDATIONS AND LIMITATIONS FOR AERIAL AND GROUND APPLIED ADULT MOSQUITO CONTROL INTERVENTIONS

1. Aerial adult mosquito control applications:
 - A. Spraying efficacy is optimized at temperatures greater than 65° F. Efficacy is reduced through the range of temperatures between 65° F. and 55° F.
 - B. Optimal efficacy is likely to occur in the evening because it is usually the period of highest mosquito activity. Efficacy should also occur in the early morning although due to lower temperatures, there is less mosquito activity than in the evening.
 - C. Atmospheric turbulence is more stable in the evening and early morning. This condition contributes to effective applications.
 - D. Higher wind speeds increase efficacy in areas with dense vegetation.
 - E. Larger droplet sizes within the legal range are more effective.
 - F. Higher application rates within the legal range are more effective. In areas with dense vegetation that limits efficacy, higher application rates are recommended.
 - G. Wide scale aerial applications done in a short time frame should reduce migration of mosquitoes from untreated areas into treated areas. These mosquitoes may be virus-laden. Although undocumented, the intervention subcommittee believes this recommendation contributed to the effectiveness of the 1990 EEE intervention.
2. Ground applied adult mosquito control applications:
 - A. Spraying efficacy is optimized at temperatures greater than 65° F. Efficacy is reduced through the range of temperatures between 65° F. and 55° F.
 - B. Optimal efficacy is likely to occur in the evening because it is usually the period of highest mosquito activity. Efficacy should also occur in the early morning although due to lower temperatures, there is less mosquito activity than the evening.
 - C. Atmospheric turbulence is more stable in the evening and early morning. This condition contributes to effective applications.
 - D. Higher wind speeds increase efficacy in areas with dense vegetation.
 - E. Larger droplet sizes within the legal range are more effective.
 - F. Higher application rates within the legal range are more effective. In areas with dense vegetation that limits efficacy, higher application rates are recommended.
 - G. Without a dense network of streets in a neighborhood or around a school, truck mounted aerosol applications cannot be relied upon to provide effective control. Wide area coverage in areas with a dense network of streets is necessary to reduce migration of mosquitoes from untreated areas into treated areas. These mosquitoes may be virus-laden.

- H. The most effective control at school playgrounds and at recreation areas can be achieved through ground applied aerosols to perimeter neighborhoods containing a dense network of streets in as large an area as possible or applying a barrier spray with a residual pyrethroid to bordering vegetated areas or a combination of the two methods.
- I. For controlling adult stage *Culex* mosquitoes, there is conflicting evidence that ground applied aerosols are effective. Two ground applied aerosol applications within a week will increase efficacy.
- J. Regulatory impacts attributed to the Children and Family Protection Act, the Massachusetts Endangered Species Act and the Massachusetts Pesticide Control Act allow for exclusions from control in a network of streets that limit effectiveness. (Figures 1, 2, and 3).
- K. In urban areas with traffic and pedestrian activity, tradeoffs to efficacious control may have to be made. Adult mosquito control applications may have to be scheduled later at night or near dawn.

ANNOTATED BIBLIOGRAPHY

Anderson, A., C. Apperson, et al. (1991). "Effectiveness of Mist -Blower Applications of Malathion and Permethrin to Foliage as Barrier Sprays for Salt Marsh Mosquitoes." American Mosquito Control Association **7**(1): 116-117.

Permethrin and malathion were applied as salt marsh mosquito barriers by mist-blower to the shrub border of a park. At one and 24 hours after treatment, mosquito landing counts in both insecticide treated areas declined by 80-90% relative to counts in an untreated control area. After 48 h, in the malathion-treated area, mosquito activity returned to levels observed in the control area. From 2 to 8 days post-treatment, mosquito landing counts in the permethrin-treated area remained depressed and significantly ($p < 0.01$) different from the malathion-treated and control areas. On day 9 and 10 post-treatment, mosquito landing rates returned in high levels in the insecticide treated and counted areas.

Brown, J. R., R. E. Mickle, et al. (2003). "Optimizing an aerial spray for mosquito control." Journal of the American Mosquito Control Association **19**(3): 243-250.

The role of proper flight line positioning was demonstrated to be critical for maximizing product efficacy when spraying in crosswinds by small-droplet spray strategies. Characterization studies indicated clearly that aircraft height, small drop emission distribution, and the ambient winds combine to dilute the spray cloud before impacting surface targets. A 5-fold increase in mortality was achieved when we used optimization techniques to position the aircraft during a crosswind treatment test.

Brown, J. R., W. H. Reynolds, et al. (2005). "Aerial optimization and canopy penetration study of Dibrom 14 Concentrate." Journal of the American Mosquito Control Association **21**(1): 106-113.

This document describes the results of collaborative trials between St. Tammany Parish Mosquito Control, ADAPCO, Inc., and the Navy Disease Vector Ecology and Control Center, Naval Air Station, Jacksonville, FL. These tests provide data on the aerial optimization testing of Dibrom 14 Concentrate adulticide. During the week of June 17, 2002, 1 canopy penetration and 3 optimization studies were conducted in St. Tammany Parish, LA, using a Britton Norman twin turbine Islander equipped with 10-800067 flat fan nozzles. Dibrom 14 Concentrate (AMVAC Chemical Corp., Los Angeles, CA) was applied at 3.12 liter per min from a release height of 60.96 m above ground level (agl) at 140 kts indicated airspeed. This resulted in an application rate of 0.65 oz/acre.

Brown, J. R., W. E. Steinke, et al. (1998). "Aqua-reslin(R) droplet analysis." Journal of the American Mosquito Control Association **14**(4): 467-469.

Aerosol droplets were collected, counted, and sorted using a laser system, the Army Insecticide Measuring System, Teflon(R)-coated slides, and magnesium oxide-coated slides. All droplets, for each method and

replication, were generated by a London Aire 1820 or a Leco Model 1600. These data indicate that the Army Insecticide Measuring System or Teflon-coated slides are so closely similar to the laser that they could effectively be used in the field without an overwhelming loss in precision.

Crockett, R. J., J. A. Dennett, et al. (2002). "Efficacy of Biomist 30:30 and Aqua Reslin Against *Anopheles quadrimaculatus* in Arkansas." Journal of the American Mosquito Control Association **18**(1): 68-69.

Aqua Reslin and Biomist 30:30 technical permethrin and piperonyl butoxide were applied via ground ultra-low volume at a rate of 237 ml/min and 0.00196 kg active ingredient/ha against wild-caught adult *Anopheles quadrimaculatus*. The 2 formulations did not differ significantly at 31 m from the spray path ($P < \text{or} = 0.05$). However, at 61 and 91 m, percent mortality for 30:30 was significantly higher than for Aqua Reslin at each time after treatment ($P < \text{or} = 0.05$). Between 12 and 24 h, about 8% recovery was observed in mosquitoes treated with Aqua Reslin at 31 m.

Curtis, G. A. and E. J. Beidler (1996). "Influence of ground ULV droplet spectra on adulticide efficacy for *Aedes taeniorhynchus*." Journal of the American Mosquito Control Association **12**(2 PART 2): 368-371.

A series of 76 field trials in a vegetated habitat with caged adult *Aedes taeniorhynchus* mosquitoes determined that ground ultra-low volume treatment efficiency was significantly influenced by droplet size. Small droplets (7- μ m volume median diameter (VMD)) produced the lowest mosquito mortality at all test distances (100-500 ft.). A VMD of 26 μ m was effective at 100-300 ft., but was not effectual at 400-500 ft. Droplets in the 15- μ m range were the most effective overall, at the distances evaluated.

Curtis, G. A. and J. Mason (1988). "Evaluation of Equipment Modifications and Dosage Rates of Ground ULV Applications of Naled against *Aedes-Taeniorhynchus* in a Florida USA Citrus Grove." Journal of the American Mosquito Control Association **4**(3): 345-350.

Efficiency of ground-applied naled (Dibrom 14), based on caged mosquito bioassays in a moderately vegetated coastal southeastern Florida citrus grove, proved to be significantly associated with downwind distance. However, association analysis between wind speed, temperature or relative humidity revealed no correlation between these meteorological factors and mosquito mortality. Tests conducted with 3 of the commonly used ULV machines demonstrated no significant differences in efficiency. Equipment modifications to simulate aerial application by elevating the spray release point proved ineffective. Increasing the dosage of naled to 3 times the labeled rate for ground treatment resulted in greater than 95% mortality.

Efird, P. K., A. D. Inman, et al. (1991). "Efficacy of Various Ground-Applied Cold

Aerosol Adulticides against *Anopheles-Quadrimaculatus*." Journal of the American Mosquito Control Association **7**(2): 207-209.

Ground-applied ULV, cold aerosol insecticides were tested against adult female *Anopheles quadrimaculatus*. Treatments included high (H) and low (L) rates of Permanone (permethrin), bioresmethrin and esbiothrin. Malathion was applied as a strand. Mortality at 24-h posttreatment was highest with Bioresmethrin H at 15 m. Permanone H exhibited good control out to 60 m (88.9%), but dropped to an unacceptable level (65.5%) at 90 m. The low rates of all compounds produced unsatisfactory results at 24-h posttreatment. Recovery from knockdown occurred in all treatments with the exception of malathion.

Efird, P. K., A. D. Inman, et al. (1992). "Efficacy of Various Ground-Applied Pyrethroids against Adult *Anopheles-Quadrimaculatus* in the Rice Growing Region of Arkansas." Journal of the American Mosquito Control Association **8**(1): 77-79.

Ground-applied ULV, cold aerosol, insecticide sprays were evaluated against caged adult female *Anopheles quadrimaculatus*. Treatments included 2 rates each of resmethrin, permethrin and a water-based permethrin formulation. Mortality at 24 h posttreatment was not significantly ($P \geq 0.05$) different between the resmethrin and water-based permethrin treatments. Both rates of permethrin were significantly ($P < 0.05$) less effective than the other treatments.

Eliason, D. A., E. G. Campos, et al. (1990). "Apparent Influence of the Stage of Blood Meal Digestion on the Efficacy of Ground Applied ULV Aerosols for the Control of Urban *Culex* Mosquitoes Ii. Laboratory Evidence." Journal of the American Mosquito Control Association **6**(3): 371-375.

The susceptibility of adult *Culex pipiens* s.l., *Culiseta melanura* and *Aedes aegypti* to insecticide aerosols in wind tunnel exposures varied with time, depending on the stage of blood meal digestion. Greater than 2-fold differences were observed in the concentrations of malathion and synergized resmethrin required to kill test mosquitoes, depending on whether they had been given a blood meal and, if they had, the length of time following the blood meal. The period of lowest susceptibility varied from 24 h after feeding in *Ae. aegypti* to 72 h in *Cs. melanura*. The greatest variability occurred during the period when undigested blood was present. Data from tests with a malathion-tolerant strain of *Cx. pipiens* s.l. suggested little change in susceptibility regardless of blood feeding and the associated weight changes that occur from ingestion of blood.

Floore, T. G., C. B. J. Rathburn, et al. (1992). "Comparison of the Synthetic Pyrethroids Esbiothrin and Bioresmethrin with Scourge and Cythion against Adult Mosquitoes in a Laboratory Wind Tunnel." Journal of the American Mosquito Control Association **8**(1): 58-60.

Both candidate adulticides, Esbiothrin and Bioresmethrin, exhibited quick

knockdown 1-h posttreatment. Esbiothrin elicited the fastest knockdown, but Bioresmethrin was more effective at both 1- and 24-h posttreatment than either Esbiothrin or Scourge against both *Aedes taeniorhynchus* and *Culex quinquefasciatus*. Mosquitoes treated with Scourge required more time and a higher dosage to respond in a physiological manner similar to those treated with either of the candidate adulticides. More than twice the dosage rate of Cythion was required than either candidate adulticide to cause a similar physiological response in treated mosquitoes.

Groves, R. L., D. A. Dame, et al. (1997). "Efficacy of three synthetic pyrethroids against three mosquito species in Arkansas and Louisiana." Journal of the American Mosquito Control Association **13**(2): 184-188.

Adult mortality of *Anopheles quadrimaculatus*, *Culex quinquefasciatus*, and *Aedes sollicitans* was observed following ultra-low-volume (ULV) exposure to Responde, Permanone 31-66 RTU, and Scourge. Permanone 31-66 RTU (1:2.13, permethrin:PBO) and Scourge (1:3, resmethrin:PBO) were applied at 0.00175 lb AI/acre, while Responde (1:3, prallethrin:PBO) was applied at 0.001 lb AI/acre, and all were evaluated at 100, 200, and 300 ft. downwind of application. Significant mortality differences ($P \leq 0.05$) were observed among all compounds at 15 min and at 1, 12, and 24 h posttreatment against *An. quadrimaculatus* and *Cx. quinquefasciatus*. Responde exhibited significantly greater ($P \leq 0.05$) control (knockdown) against *An. quadrimaculatus* at both 15 min and 1 h posttreatment than did Permanone 31-66 RTU or Scourge; however, some recovery occurred by 12 h posttreatment. At 15 min posttreatment, Responde and Scourge were significantly ($P \leq 0.05$) more effective against *Cx. quinquefasciatus* than Permanone 31-66 RTU except at 300 ft. downwind. where Scourge was significantly ($P \leq 0.05$) more effective than either compound. No significant mortality differences ($P \leq 0.05$) were observed among the 3 compounds at 15 min, 1 h, 12 h, and 24 h posttreatment when tested against *Ae. sollicitans*. No significant mortality differences ($P \leq 0.05$) were observed between the 1:3 and 1:5 (prallethrin: piperonyl butoxide) formulations of Responde at any time posttreatment when tested against *Ae. sollicitans*.

Groves, R. L., J. C. McAllistar, et al. (1994). "Evaluation of aerial and ground-applied adulticides against mosquito species in Arkansas and Louisiana." Journal of the American Mosquito Control Association **10**(3): 407-412.

Mosquitoes were subjected to ultra-low volume (ULV) aerial applications of permethrin synergized with piperonyl butoxide (Biomist 30:30, Biomist 31:66) and Cythion and ULV ground applications of permethrin synergized with piperonyl butoxide (Biomist 30:30, Biomist 12:60), resmethrin (Scourge), and sumithrin (Solo 40-OS and Duets 8.8-OS). Permethrin compounds tested aerially against *Anopheles quadrimaculatus* were not significantly different. Biomist 30:30 tested aerially against *Culex quinquefasciatus* did provide significantly greater mortality compared to

Cythion. Biomist 30:30 and Biomist 31:66 tested aerially against *An. quadrimaculatus* at 1 h did not provide a significant difference up to 600 ft. (182.9 m). Both products ground tested at 24 h revealed nonsignificant results. Biomist 30:30 and Biomist 12:60 ground tested against *Cx. quinquefasciatus* at 1 h did not provide a significant difference at 100 ft. (30.5 m) or 200 ft. (61.0 m); however, significantly greater mortality was observed at 300 ft. (61.0 m) and 600 ft. (91.4 m). At 24 h no significant mortality differences were observed at 300 ft. (61.0 m) and 600 ft. (91.4 m). *Anopheles quadrimaculatus* and *Psorophora columbiae* were treated with a 1:1 mixture of Solo 40-OS and Duet 8.8-OS (sumithrin + piperonyl butoxide). Significant mortality differences ($P \leq 0.05$) between species at 1 h posttreatment occurred at 300 ft. (91.4 m).

Groves, R. L., M. V. Meisch, et al. (1995). "Efficacy of a 1:1 and 1:5 mixture of technical permethrin and piperonyl butoxide against *Anopheles quadrimaculatus* and *Psorophora columbiae*." Journal of the American Mosquito Control Association **11**(3): 311-314.

Anopheles quadrimaculatus and *Psorophora columbiae* adults were treated with a 1:1 and 1:5 mixture of technical permethrin and piperonyl butoxide. These mixtures (0.00075 lb AI/acre) at 100, 200, and 300 ft. downwind of application killed a similar ($P \leq 0.05$) percentage of *Ps. columbiae* ranging from 45.1 to 68.8% and 85.7 to 100.0% after 1 and 24 h posttreatment, respectively. Similar results were obtained at 1 and 24 h posttreatment against *An. quadrimaculatus* (0.00075 lb AI/acre) where percentage mortality ranged from 42 to 62% and 63 to 78% after 1 and 24 h posttreatment, respectively. At 24 h posttreatment, significantly more mortality ($P \leq 0.05$) occurred in *An. quadrimaculatus* than in *Ps. columbiae* for both the 1:1 and 1:5 formulations above, except at 100 ft. downwind. A higher dosage against *An. quadrimaculatus* (0.001 lb AI/acre) resulted in a higher mean mortality at 1 h posttreatment (45.1-79.1%) and 24 h posttreatment (59.2-86.0%) than at the lower dosage. A 25% increase in permethrin (0.001 lb AI/acre) vs. a 400% increase in piperonyl butoxide alone gave increases in mortality of 30.4% vs. 8.6%, respectively.

Ham, C. M., M. V. Meisch, et al. (1999). "Efficacy of Dibrom(R), Trumpet(R), and Scourge(R) against four mosquito species in Louisiana." Journal of the American Mosquito Control Association **15**(4): 433-436.

Adult mortality of *Anopheles quadrimaculatus*, *Culex quinquefasciatus*, and the *Aedes* spp. complex (*Aedes sollicitans* and *Aedes taeniorhynchus*) was observed after aerial ultra-low volume (ULV) exposure to Dibrom(R), Trumpet(R), and Scourge(R). Dibrom was applied at 112 g active ingredient (AI)/ha, Trumpet at 112 g AI/ha, and Scourge at 1.96 g AI/ha. At all time intervals, Dibrom and Trumpet were significantly more effective against the *Aedes* spp. complex than against *An. quadrimaculatus* and *Cx. quinquefasciatus*. Scourge was significantly more effective against *An. quadrimaculatus* and *Cx. quinquefasciatus* than

Dibrom or Trumpet. Trumpet was evaluated at lower labeled rates (28, 56, and 84 g AI/ha) against *Cx. quinquefasciatus* and the *Aedes* spp. complex. Adult mortality with Trumpet increased significantly at 1 and 24 h against *Cx. quinquefasciatus*. With the *Aedes* spp. complex, mortality increased with rate at 1 h, but at 12 and 24 h, the medium and high dosages were not significantly different from each other. *Culex quinquefasciatus* and the *Aedes* spp. complex were also subjected to ULV ground applications of Dibrom, Trumpet, and Scourge. Dibrom was applied at 22.4 g AI/ha, Trumpet at 22.4 g AI/ha, and Scourge as a 1:6 mineral oil mixture at 1.96 g AI/ha. Relative to Dibrom and Trumpet, mortality from Scourge differed greatly with mosquito species. Against *Cx. quinquefasciatus*, Scourge was significantly more effective than Dibrom and Trumpet at all times and distances, but against the *Aedes* spp. complex Scourge was significantly less effective.

Hubbard, J. L., R. T. Trout, et al. (2005). "Do Backyard Mosquito Sprays Work?" Pest Control Technology Online **May**(2005): 1-4.

None available

Knepper, R. G. (1988). "Efficacy of a ULV Insecticide Mixture Han-Malathion-Resmethrin against Caged *Culex* Mosquitoes." Journal of the American Mosquito Control Association **4**(4): 561-562.

None available

Latham, M. (2000). "An Overview of Mosquito Control Adulticiding". Presentation at the Lee County Mosquito Control District, Florida.

Ground (truck ULV): less expensive, better droplet spectrum, lower application rates (organophosphates), less off-target drift and moderate ability to avoid "No Spray" zones, applied to target environment, smaller area coverage, limited to good street network, limited by traffic/Congestion and not limited by ambient light.

Air (aerial ULV); more expensive, larger drop size = waste or damage, higher application rates (organophosphates), greater off-target drift and inability to avoid small "No Spray" zones, applied above target environment, applied above target environment, more expensive, covers large areas quickly and not limited by street network.

Lesser, C. R. (2002). "Field Trial Efficacy of Anvil 10+10 and Biomist 31:66 Against *Ochlerotatus sollicitans* in Delaware." Journal of the American Mosquito Control Association **18**(1): 36-39.

Anvil 10+10 (hereafter Anvil) and Biomist 31:66 (hereafter Biomist) were applied by ground ultra-low volume (ULV) methods to determine the effectiveness of each formulation against *Ochlerotatus sollicitans*. Each formulation was tested at 50, 67, and 100% of respective maximum label dosage rates. Mosquitoes were exposed in cages on a 3 x 3 grid at

distances of 30.5, 60.9, and 91.4 m. Mortality data were collected at intervals of 1, 4, and 12 h after treatment. No significant differences ($P > \text{or} = 0.05$) were found among formulations at applications of 100% of the label rate and no significant differences ($P > \text{or} = 0.05$) were found between Anvil applied at 100% of the label rate and Biomist applied at 50 and 67% of label rates. Ground ULV applications of Anvil at 100% label rate and Biomist at all tested rates were effective ($> \text{or} = 95\%$ mortality) adulticides. Applications of Anvil at 50 and 67% label rates were significantly less effective ($P < \text{or} = 0.05$) than applications of Biomist at equal percentages of the maximum label rate. Applications of Anvil at rates of 50 and 67% were not effective.

Linley, J. R. and S. Jordan (1992). "Effects of Ultra-Low Volume and Thermal Fog Malathion Scourge and Naled Applied against Caged Adult *Culicoides-furens* and *Culex-Quinquefasciatus* in Open and Vegetated Terrain." Journal of the American Mosquito Control Association 8(1): 69-76.

The adulticidal effect of ULV and thermal fog malathion, Scourge and naled was tested at 2.times. label dosage (1.42, 0.22, 0.39 oz/acre, respectively) against caged *Culicoides furens* and *Culex quinquefasciatus* in open and vegetated (orange grove) terrain. Cages were at 122 cm elevation and positioned at 15.2, 45.7, 76.2, 106.7, 137.2 and 167.6 m from the line of insecticide release. Ultra-low volume applications of all 3 insecticides were markedly more effective than thermal fog under all conditions, especially against *Cx. quinquefasciatus* (in which there was some resistance) and particularly when applied as thermal fog. Scourge and naled were about equally effective. The best adulticide against *C. furens* was naled, which was clearly superior applied as ULV. It yielded 75% mortality out to 283 m in the open, and to 38 m in the presence of dense vegetation.

Linley, J. R., R. E. Parsons, et al. (1988). "Evaluation of ULV Naled Applied Simultaneously against Caged Adult *Aedes-Taeniorhynchus* and *Culicoides-furens*." Journal of the American Mosquito Control Association 4(3): 326-332.

Two experiments were conducted to test application of ULV naled against adult *Aedes taeniorhynchus* and *Culicoides furens* exposed simultaneously in cages hung on poles at selected heights and distances from the spray source. ULV spray was released at 0.14 oz active ingredient/acre, droplet size 13.5 μm mmd. In both experiments, insecticide largely carried over the first poles. The greatest mortality occurred at the second pole position, 18.3 and 25.7 m, respectively, from the spray origin, and diminished progressively with increasing distance. Cages at the highest elevation (183 cm) showed the greatest mortality, while those near the ground (15 cm) were substantially less affected. Regression analysis showed that 70% control or better was attained up to a distance (beyond a line 10 m from the release point) of 23 m in the case of *Ae. taeniorhynchus* and 18 m in the case of *C. furens*. ULV naled, as

applied as described, was not particularly effective for control of *Ae. taeniorhynchus* and *C. furens*, and was poor for insects exposed in low vegetation.

Liu, W., R. G. Todd, et al. (1986). "Effect of three pyrethroids on blood feeding and fecundity of *Aedes aegypti*." J Am Mosq Control Assoc **2**(3): 310-313.

Caged *Aedes aegypti* were exposed to a range of concentrations of d-phenothrin, d-allethrin and tetramethrin in a wind tunnel. Mortality, blood engorgement and egg production among these mosquitoes and their progeny were recorded. Tetramethrin was the most effective (LC50 of 0.0017%), followed by d-phenothrin (LC50 0.0031%) and d-allethrin (LC50 0.01%). Blood engorgement was decreased by treatment with each pyrethroid at the high concentration (0.002%, 0.003% and 0.01% respectively). Treatment with d-phenothrin or d-allethrin decreased egg production, but tetramethrin increased oviposition. These effects had ceased in the F2.

Meisch, M. V., D. A. Dame, et al. (2005). "Aerial ultra-low-volume assessment of anvil 10+10 (R) against *Anopheles quadrimaculatus*." Journal of the American Mosquito Control Association **21**(3): 301-304.

Against caged field-collected adults of *Anopheles quadrimaculatus*, optimized aerial applications of ANVIL 10 +10 (R) at 18.4 ml (1.63 g active ingredient)/0.4 ha produced a mean mortality of 92% at 1, 12, and 24 h after treatment. These trials were conducted with 7 stacked passes applied 1,067 m upwind of the target site when wind velocity was 18-21 km/h at an application altitude of 46 m and 5-10 km/h at ground level. When the wind velocity aloft was greater than might be operationally acceptable (27 km/h), reduced efficacy (64% mortality) was observed in the bioassay site (1,524 m downwind from 11 stacked passes) in an unreplicated application. Droplets from the 2 tail-mounted Beecomist 360-A-12-V rotary atomizers (fitted with wire sleeve cages of size 40 mesh) collected on spinning Teflon (R)-coated slides in the target area averaged a volume mean diameter (VMD) of 29 µm and a droplet density of 39 droplets/cm(2) in 18- to 21-km/h winds. With 27-km/h winds aloft and a greater application offset, the VMD and droplet density dropped to 23 µm and 18 droplets/cm(2), respectively. Coupled with unreplicated results from a nonoptimized application, these tests provide further documentation of the efficacy of ANVIL 10+10 for wide-area adult mosquito control and for optimization technology.

Meisch, M. V., D. A. Dame, et al. (1994). "Assessment of *Anopheles quadrimaculatus* response to permethrin and resmethrin by topical application." Journal of the American Mosquito Control Association **10**(3): 437-439.

Topical applications with field-captured mosquitoes provided LD-50 estimates ranging from 13.3 to 20.0 ppm for permethrin and 8.5 to 18.9 ppm for resmethrin in the Stuttgart, AR, area in 1993. Mosquitoes

collected from the abatement area appeared to be more susceptible to resmethrin than those from outside the area (8.5 ppm vs. 18.9 ppm). The observed difference was not great enough to be of concern from an economic or control standpoint. The data provided a firm baseline for future assessment of changes in susceptibility to these 2 materials. Mosquitoes collected in Walnut Ridge, AR, were susceptible to permethrin and resmethrin within the same range as the Stuttgart populations, but the limited numbers of observations preclude firm LD-50 estimates.

Meisch, M. V., C. L. Meek, et al. (1997). "Field trial efficacy of two formulations of Permanone against *Culex quinquefasciatus* and *Anopheles quadrimaculatus*." Journal of the American Mosquito Control Association **13**(4): 311-314.

Tests were conducted during the summer of 1996 to evaluate the effectiveness of different formulations of permethrin, Permanone 31-66 and Aquireslin, against *Anopheles quadrimaculatus* and *Culex quinquefasciatus*. Tests of both formulations were conducted at rates of 2.019 and 3.926 g AI/h with each formulation/rate replicated 3 times. Results indicate significantly greater control of both pest species at the higher application rate for both formulations. The high rate of Permanone 31-66 proved more effective than that of Aquireslin. Exposure at the low rate for both formulations provided inadequate adult control that was particularly pronounced against *Cx. quinquefasciatus*. Regardless, negligible recovery of exposed adults was observed at any formulation/rate. No significant differences in mortality were noted for any formulation/rate relative to distance downwind. However, volume median diameter and droplets/cm² were significantly affected by distance downwind. Furthermore, volume median diameter and droplets/cm² were both determined to significantly affect mortality in both mosquito species ($P \leq 0.05$). Overall, results indicate that Permanone 31-66 and Aquireslin applied at a rate of 3.926 g AI/h were effective.

Moore, C. G., P. Reiter, et al. (1990). "Apparent Influence of the Stage of Blood Meal Digestion on the Efficacy of Ground Applied ULV Aerosols for the Control of Urban *Culex* Mosquitoes Iii. Results of a Computer Simulation." Journal of the American Mosquito Control Association **6**(3): 376-383.

When posttreatment response to ultra low volume (ULV) application of insecticide has been followed for periods approaching a week, a damped oscillation in oviposition rates is observed, probably because females who have been recently blood-fed are more resistant to insecticides than their unfed siblings. We describe a simple model (ULVSIM) that incorporates physiologic changes in insecticide susceptibility and accounts for much of our field data. The model follows 30 cohorts over 30 days following insecticidal treatment. Multiple treatments or short-term residual activity can be evaluated. The model predicts that oviposition will follow a pattern of damped oscillations after an adulticidal treatment. The model gave a good fit to oviposition data obtained in 2 field trials of resmethrin for 7 to 9

days after treatment. It can be used to evaluate the effect of single and multiple treatments on the total female *Culex* population and on numbers of infected females surviving for different periods following an infective blood meal.

Mount, G. A. (1998). "A critical review of ultralow-volume aerosols of insecticide applied with vehicle-mounted generators for adult mosquito control." Journal of the American Mosquito Control Association **14**(3): 305-334.

This review of ultralow-volume (ULV) ground aerosols for adult mosquito control includes discussion on application volume, aerosol generators, droplet size, meteorology, swath, dispersal speed, assay methods, insecticide efficacy, and nontarget effects. It summarizes the efficacy of ULV insecticidal aerosols against many important pest and disease-bearing species of mosquitoes in a wide range of locations and habitats in the United States and in some countries of Asia and the Americas. Fourteen conclusions were drawn from the review. 1) ULV ground aerosol applications of insecticide are as efficacious against adult mosquitoes as high- or low-volume aerosols. 2) ULV aerosols with an optimum droplet size spectrum can be produced by several types of nozzles including vortex, pneumatic, and rotary. Droplet size of a particular insecticide formulation is dependent primarily on nozzle air pressure or rotation speed and secondarily on insecticide flow rate. 3) Label flow rates of insecticide for ULV aerosol application can be delivered accurately during routine operations with speed-correlated metering systems within a calibrated speed range, usually not exceeding 20 mph. 4) The most economical and convenient method of droplet size determination for ULV aerosols of insecticide is the waved-slide technique. 5) The efficacy of ULV ground aerosols against adult mosquitoes is related to droplet size because it governs air transport and impingement. The optimum droplet size for mosquito adulticiding is 8-15 μm volume median diameter (VMD) on the basis of laboratory wind-tunnel tests and field research with caged mosquitoes. 6) In general, ULV aerosols should be applied following sunset when mosquitoes are active and meteorological conditions are favorable for achieving maximum levels of control. Application can be made during daytime hours when conditions permit, but rates may have to be increased. The critical meteorological factors are wind velocity and direction, temperature, and atmospheric stability and turbulence. 7) Maximum effective swaths are obtained with aerosols in the optimum VMD range during favorable meteorological conditions in open to moderately open terrain. The insecticide dosage must be increased in proportion to increased swath to maintain the same level of mosquito control. 8) Dispersal speed within a range of 2.5-20 mph is not a factor affecting efficacy if insecticide rate and optimum droplet size are maintained. 9) The results of caged mosquito assays are comparable with reductions in free-flying natural populations. 10) The field efficacies of mosquito adulticides applied as ULV ground aerosols are predictable from

the results of laboratory wind-tunnel tests. 11) Results of field tests in open to moderately open terrain during favorable meteorological conditions indicated that ULV insecticidal aerosol application rates producing 90% or more control of *Anopheles*, *Culex*, and *Psorophora* spp. are below or -equal to maximum United States Environmental Protection Agency label rates. Against some *Aedes* spp., some pyrethroid insecticides must be synergized to produce 90% control at label rates. 12) Results of field tests in residential areas with moderate to dense vegetation and in citrus groves or other densely wooded areas showed that insecticide rates of ULV ground aerosols must be increased 2-3-fold to obtain 90% or more control of adult mosquitoes. However, the maximum rates on some insecticide labels would have to be increased to allow higher application rates. 13) Applications of ULV ground aerosols of insecticide in accordance with label directions following sunset do not pose a serious threat to humans, nontarget beneficial animals, or automotive paints. 14) Some aerosol generators operated at high RPM levels exceed the OSHA 8-h hearing hazard criteria of 90 dBA and may require hearing protectors for operators.

Mount, G. A., T. L. Biery, et al. (1996). "A review of ultralow-volume aerial sprays of insecticide of mosquito control." Journal of the American Mosquito Control Association **12**(4): 601-618.

This review of research on ultralow-volume (ULV) aerial sprays for mosquito control is a component of an Aerial SPray EXpert system (ASPEX). Topics include application volume, adulticiding, larviciding, droplet size, and meteorology. The review discusses the efficacy of ULV aerial sprays against many important pest and vector species of mosquitoes in a wide range of locations and habitats in the USA and in some countries of Asia, Africa, and the Americas. Nine conclusions were drawn from this review. 1) ULV applications are as effective for mosquito control as highly-diluted, water-based sprays. 2) More acres can be sprayed per aircraft load with the ULV method than with dilute sprays. 3) High-altitude ULV sprays using wide or stacked swaths could be used in emergencies if wind speed and direction data at appropriate altitudes are available to accurately place the spray. 4) Successful adult mosquito control can be achieved in dense foliage or open housing with ULV aerial sprays, but doses of insecticide must be increased. 5) ULV aerial application of mosquito larvicides can be used successfully in large areas. 6) The optimum droplet size for adult mosquito control is 5-25 μm volume median diameter (VMD). 7) For mosquito adulticiding, near optimum atomization of ULV sprays is achieved with flat-fan nozzles oriented straight down or slightly forward for high-speed aircraft (≥ 150 mph) or rotary atomizers on slow-speed aircraft (≥ 150 mph). 8) Optimum atomization minimizes paint spotting. 9) Maximum adult mosquito control is achieved just after sunrise and just before sunset with 2-10-mph crosswinds.

Perich, M. J., B. L. Bunner, et al. (1992). "Penetration of Ultra-Low Volume Applied Insecticide into Dwellings for Dengue Vector Control." Journal of the American Mosquito Control Association **8**(2): 137-142.

Determinations on the penetration of ultra-low volume applied insecticide into dwellings was accomplished with a model house in Frederick, MD, USA, and native houses in Santo Domingo, Dominican Republic. Results from the model house tests show that aerosol droplets, with a volume median diameter of 4 μm , penetrated and remained suspended in low recesses of the building during the first 2 min after spraying. Similar results were found with tests in Santo Domingo, where man-made or natural obstructions were determined to be critical factors in aerosol penetration.

Perich, M. J., M. A. Tidwell, et al. (1993). "Barrier spraying to control the malaria vector *Anopheles albimanus*: Laboratory and field evaluation in the Dominican Republic." Medical & Veterinary Entomology **7**(4): 363-368.

To develop a new strategy for control of exophilic/exophagic malaria vectors, which rest on peridomestic foliage, *Anopheles albimanus* was used for laboratory bioassays of mosquito adulticides applied to various vegetation types. Of the three classes of insecticide tested, the pyrethroid (permethrin at 112 g/ha) showed greater foliar persistence than either the carbamate (bendiocarb at 340 g/ha) or the organophosphorus compound (malathion at 277 g/ha). Field evaluation of barrier spraying against *An. albimanus* was evaluated in rural villages of southwest Dominican Republic during 1989. The pyrethroid deltamethrin was sprayed aerially for ultra-low volume application at treatment rates of 17-19 g a.i./ha in a radius of 500 m around two villages. *An. albimanus* were monitored by light-traps and human bait collections at both treated villages, compared with two similar untreated villages, up to 9 nights posttreatment. Densities of female *An. albimanus* were significantly reduced in the sprayed villages for at least 8 or 9 nights. Further evaluation of barrier spraying is recommended to determine optimal pyrethroid formulations and applications rates, their impact on non-target fauna and efficacy against malaria transmission.

Perich, M. J., M. A. Tidwell, et al. (1990). "Comparison of Ground and Aerial Ultra-Low Volume Applications of Malathion against *Aedes Aegypti* in Santo Domingo Dominican Republic." Journal of the American Mosquito Control Association **6**(1): 1-6.

Efficacy of ground and aerial ultra-low volume (ULV) applications of 91% malathion at 438 ml/ha against *Aedes aegypti* in the Dominican Republic was evaluated using indoor collections, oviposition trapping and adult sentinel mortality rates. Ground compared to aerial ULV applications in this study were found to have a greater effect on *Ae. aegypti* when measured by the described sampling techniques. Neither application

method provided the level of *Ae. aegypti* suppression believed necessary for control in the event of a dengue virus epidemic.

Petersen, J. L., T. G. Floore, et al. (2004). "Diagnostic dose of synergized d-phenothrin for insecticide susceptibility testing by bottle bioassay." J Am Mosq Control Assoc **20**(2): 183-8.

The diagnostic dose of d-phenothrin synergized 1:1 with piperonyl butoxide for testing insecticide susceptibility of mosquitoes by bottle bioassay is reported for 2 mosquito species, *Culex quinquefasciatus* and *Ochlerotatus taeniorhynchus*. The diagnostic dose was defined as 2 times the 95% lethal concentration (LC95). LC50, LC90, and LC95 were estimated by probit analysis of dose response data. Procedures for diluting the commercial-grade off-the-shelf pesticide in acetone, treating the bottles, and calculating baseline data for insecticide-susceptible mosquito populations are described. The advantages and disadvantages of testing off-the-shelf commercial-grade pesticides that are maintained on premises by mosquito control programs, in contrast to using reagent-grade chemicals purchased from a chemical supply house, are also discussed. Data obtained by this method can be invaluable in making timely management decisions about the choice of pesticides in a control program.

Rathburn, C. B. and J. C. Dukes (1989). "A Comparison of the Mortality of Caged Adult Mosquitoes to the Size, Number and Volume of ULV Spray Droplets Sampled in an Open and Vegetated Area." Journal of the American Mosquito Control Association **5**(2): 173-175.

A comparison of the mortality of caged adult mosquitoes to the size, number and volume of ULV spray droplets sampled in an open and vegetated area showed that 2.5-times more droplets with 3.24-times greater volume were sampled in the open area and resulted in 10-times greater mosquito mortality.

Rathburn, C. B. J. and A. H. J. Boike (1981). "Laboratory and Field Tests Comparing Formulations of Malathion Resmethrin with Malathion for the Control of Adult Mosquitoes." Mosquito News **41**(4): 756-759.

Laboratory and field tests were conducted to determine the relative effectiveness of malathion-resmethrin mixtures and malathion only. Laboratory tests conducted with malathion susceptible species showed a slight increase in effectiveness of a 90:1 malathion-resmethrin formulation over malathion for *Culex nigripalpus* but not with *Aedes taeniorhynchus*. With malathion resistant *A. taeniorhynchus*, there was no significant difference between the 100:1 malathion-resmethrin formulation and malathion. In the field tests, both technical and dilute formulations were used in tests against *C. nigripalpus*, *C. quinquefasciatus* and *A. taeniorhynchus*. These tests showed no difference in mortality between any of the malathion-resmethrin formulations used and malathion but

indicated that the differences in mortality obtained were dependent on the actual amount of malathion discharged regardless of the addition of resmethrin.

Rathburn, C. B. J., A. H. J. Boike, et al. (1981). "Field Tests of Insecticides Applied as Ultra Low Volume Sprays by Ground Equipment for the Control of Adult Mosquitoes." Mosquito News **41**(1): 132-135.

Field tests of several insecticides applied as ULV sprays by ground equipment were conducted using caged adult *Aedes taeniorhynchus* (Wiedemann) and *Culex nigripalpus* Theobald. Satisfactory mortalities of both species were obtained with chlorpyrifos (Dow MFC), fenitrothion (Sumithion Concentrate); phenthoate (Cidial ULV); propoxur (Baygon 1 MOS); and 3% naled (Dibrom 14) in various diluents including heavy aromatic naphtha (HAN); Chevron 400 solvent, and diesel oil plus 3% Ortho Additive. Resmethrin (20% SBP-1382 18.5MF in Klearol) gave excellent mortality of *C. nigripalpus*, but poor kill of *A. taeniorhynchus*.

Rathburn, C. B. J. and J. C. Dukes (1989). "A Comparison of the Mortality of Caged Adult Mosquitoes to the Size Number and Volume of ULV Spray Droplets Sampled in an Open and a Vegetated Area." Journal of the American Mosquito Control Association **5**(2): 173-175.

A comparison of the mortality of caged adult mosquitoes to the size, number and volume of ULV spray droplets sampled in an open and vegetated area showed that 2.5-times more droplets with 3.24-times greater volume were sampled in the open area and resulted in 10-times greater mosquito mortality.

Reddy, M.R., A. Spielman, et al. (2006). "Efficacy of Resmethrin Aerosols Applied from the Road for Suppressing *Culex* Vectors of West Nile Virus." Vector-Borne and Zoonotic Diseases **6**(2): 117-127.
In Press.

Reisen, W. K., M. M. Milby, et al. (1985). "Aerial Adulticiding for the Suppression of *Culex-Tarsalis* in Kern County California USA Using Low Volume Propoxur 2. Impact on Natural Populations in Foothill and Valley Habitats." Journal of the American Mosquito Control Association **1**(2): 154-163.

A low volume formulation of propoxur wettable powder suspended in larvicidal oil was evaluated on 4 occasions in Kern Co., California during 1983 using fixed and rotary wing aerial application systems. *Culex tarsalis* abundance was suppressed significantly by all sprays, although reduction below the virus maintenance threshold of 30 females per trap night was achieved only at one foothill site. Western equine encephalomyelitis virus minimum infection rates decreased significantly after serial applications on 2 occasions at a valley site. However, virus persisted in the spray zone at minimum infection rates of > 1 per 1000 *Cx. tarsalis* females tested and transmission of virus to sentinel chickens continued. The parity rates were

reduced significantly at 2 semi-isolated foothill sites, but not at a valley site where elevated autogeny rates increased the reproductive age of the host-seeking population. Spraying during late afternoon by helicopter resulted in better control than early morning applications by fixed wing aircraft at a valley site.

Reiter, P., D. A. Eliason, et al. (1990). "Apparent Influence of the Stage of Blood Meal Digestion on the Efficacy of Ground Applied ULV Aerosols for the Control of Urban Culex Mosquitoes I. Field Evidence." Journal of the American Mosquito Control Association **6**(3): 366-370.

The impact of ULV resmethrin on urban Culex mosquitoes was evaluated in 4 field trials by monitoring daily oviposition rate. A well-defined oscillation of effect, with a period corresponding to the duration of the gonotrophic cycle, was observed. We postulate that this oscillation arises from changes in susceptibility following blood feeding and/or behavioral factors. The data indicate that a single treatment with ULV may be inadequate for the effective control of vector mosquitoes.

Roberts, R. H. (1985). "Evaluation of Cyfluthrin as a ULV Cold Aerosol against Caged Mosquitoes." Journal of the American Mosquito Control Association **1**(4): 474-476.

Cyfluthrin was evaluated against caged mosquitoes using a truck-mounted Leco HD model ULV cold aerosol generator and the results were compared to the effectiveness of malathion. Calculated effective dosages (ED) for 90% and 95% control with cyfluthrin against Aedes taeniorhynchus were 0.2 and 0.3 g AI/ha and against Anopheles quadrimaculatus were 0.09 and 0.1 g AI/ha. Cyfluthrin was about 106X more effective against An. quadrimaculatus and about 69X more effective against Ae. taeniorhynchus at the ED-95 level than malathion.

Shono, Y., V. Jean-Francois, et al. (1991). "Field evaluation of ultra-low volume applications with a mixture of d-allethrin and d-phenothrin for control of Anopheles albimanus in Haiti." J Am Mosq Control Assoc **7**(3): 494-5.

Ultra-low volume applications of d-allethrin and d-phenothrin could possibly reduce populations of Anopheles albimanus when used in conjunction with residual spraying of fenitrothion. The experiments were carried out in Les Cayes, Haiti.

Sjogren, R. D. and A. M. Frank (1979). "Effectiveness and Cost of Nonthermal Resmethrin Aerosols for Control of Aedes Mosquitoes in Wooded Areas." Mosquito News **39**(3): 597-604.

Tests were conducted by the Metropolitan Mosquito Control District [St. Paul, Minnesota, USA] to determine operational effectiveness of SBP-1382 resmethrin nonthermal aerosols delivered by ground equipment in densely wooded areas. Percent control is reported for a dosage range of 0.0007 lb AI [active ingredient]/acre to 0.007 lb AI/acre. Treatment rates higher than

those used in open areas were necessary to achieve adequate control of *Aedes* mosquitoes.

Stark, P. M., C. A. Sandoski, et al. (1985). "Ultra-Low Volume and Low Volume Applications of Resmethrin and Synergized Resmethrin against Riceland Mosquitoes." Southwestern Entomologist **10**(1): 26-31.

Resmethrin and piperonyl butoxide (PBO) synergized resmethrin were evaluated for efficacy against adult *Psorophora columbiae* (primarily) and *Anopheles quadrimaculatus* (1 application only) by ultra-low volume (ULV) and low volume (LV) aerial and ULV ground applications. Generally, lower rates of technical material, alone or synergized, could be applied by air than by ground equipment for effective mosquito control. The lowest ground applied rate of resmethrin/PBO to provide greater than 90% control was 0.00196/0.00588 kg/ha, while only 81% control was achieved using resmethrin alone at 0.00784 kg/ha. Good control was obtained by ULV and LV aerial applications of resmethrin and synergized resmethrin at all rates tested. The ULV resmethrin treatments of 0.00130 and 0.00065 kg/ha resulted in 100 and 99% control of *P. columbiae* in 1 h posttreatment and 99% control of *A. quadrimaculatus* at the lower rate in the same time frame. The lesser amount of resmethrin in the resmethrin/PBO rates applied aerially (0.00037/0.00112, 0.00029/0.00088 and 0.00023/0.00070 kg/ha) required a minimum of 6 h posttreatment to achieve > 90% control of *P. columbiae*.

Trout, R. T. and G. C. Brown (2006). "A closer look at the effectiveness of pyrethroid applications for urban mosquito management." Annual American Mosquito Control Meeting, Detroit, Michigan.

With increased public awareness of mosquito-borne threats, pest control operators are offering mosquito control services by applying adulticides to residential daytime resting sites. We evaluated the efficacy of this application technique in Lexington, Kentucky. A randomized complete block design compared two chemical application methods of one adulticide, lambda-cyhalothrin, as "backyard" mosquito control treatments. Three homes in each of eight neighborhoods (the blocking factor) were randomly assigned a water control or one of the treatment applications. Treatments were either a full thorough treatment, spritz treatment, or the control. Mosquito populations were sampled weekly using landing rates, CO₂ traps at ground level, CO₂ traps in the tree canopy, gravid traps, sweep nets, and oviposition traps. Homeowners also completed three surveys to assess their attitudes towards treat effectiveness. Additionally a second study was conducted investigating the usage of pyrethroids to treat mosquito hot spots. Mixed as it maximum label rate, lambda-cyhalothrin was applied to tree lines. Mosquito populations were monitored weekly for 10 wk with gravid traps, CO₂ traps at ground level and CO₂ traps within the tree canopy. Results from both studies will be presented.

Weathersbee, A. A., III, D. A. Dame, et al. (1989). "Susceptibility of Riceland Anopheles-Quadrimaculatus to Baytex and Scourge Ground ULV Applications." Journal of the American Mosquito Control Association 5(4): 606-607.

None available

Weathersbee, A. A., III, M. V. Meisch, et al. (1991). "Activity of Lambda Cyhalothrin Applied as an Ultralow Volume Ground Treatment against Anopheles-Quadrimaculatus Adults." Journal of the American Mosquito Control Association 7(2): 238-241.

Lambda-cyhalothrin was evaluated as an ultralow volume ground adulticide treatment at rates of 0.25, 0.5 and 1.0 g/ha. Resmethrin, a standard adulticide, was applied at a rate of 1.96 g/ha. All treatments provided $\geq 95\%$ control up to 50 m from the spray route. The highest rate of lambda-cyhalothrin and the resmethrin standard provided $\geq 95\%$ control up to 200 m, which is twice the distance normally assessed in this type of testing. Control was reduced at 200 m for the 0.25 and 0.5 g/ha rates of lambda-cyhalothrin, which provided 73 and 88% mortality, respectively. Lambda-cyhalothrin appears to have the insecticidal activity required for operational mosquito control.

Weathersbee, A. A., III, M. V. Meisch, et al. (1986). "Combination Ground and Aerial Adulticide Applications against Mosquitoes in an Arkansas USA Riceland Community." Journal of the American Mosquito Control Association 2(4): 456-460.

Simultaneous ground and aerial adulticide applications were evaluated against riceland mosquitoes in Stuttgart, AR, during July 1985. Naled was aerially applied at 52.6 ml/ha over 10.4 km² surrounding the city. Ground ULV applications of a mixture of malathion, HAN and resmethrin/PBO (1:1:0.0625) were applied within the city at a rate of 221.8 ml/min at 24 kph. Adult populations of Anopheles quadrimaculatus and Psorophora columbiae were reduced at 24 hr but resurgence of Ps. columbiae was evident at 48 hr posttreatment. Posttreatment data indicated that movement of both mosquitoes occurred along the path of prevailing wind.

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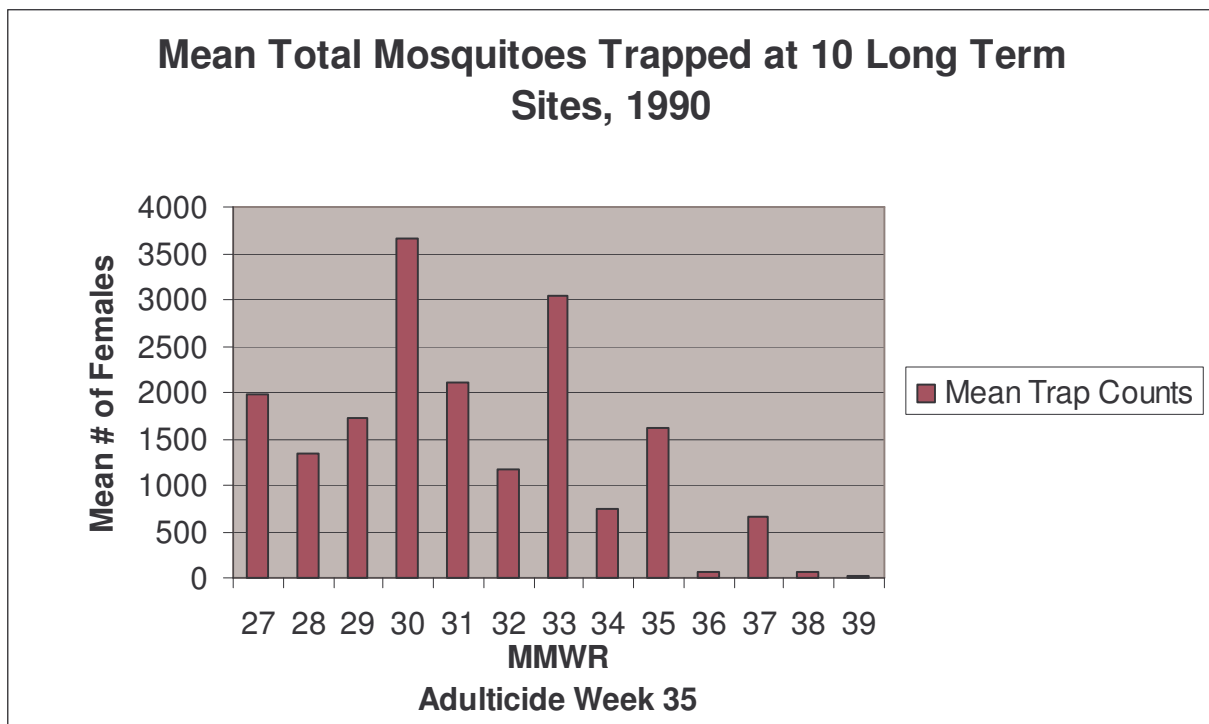
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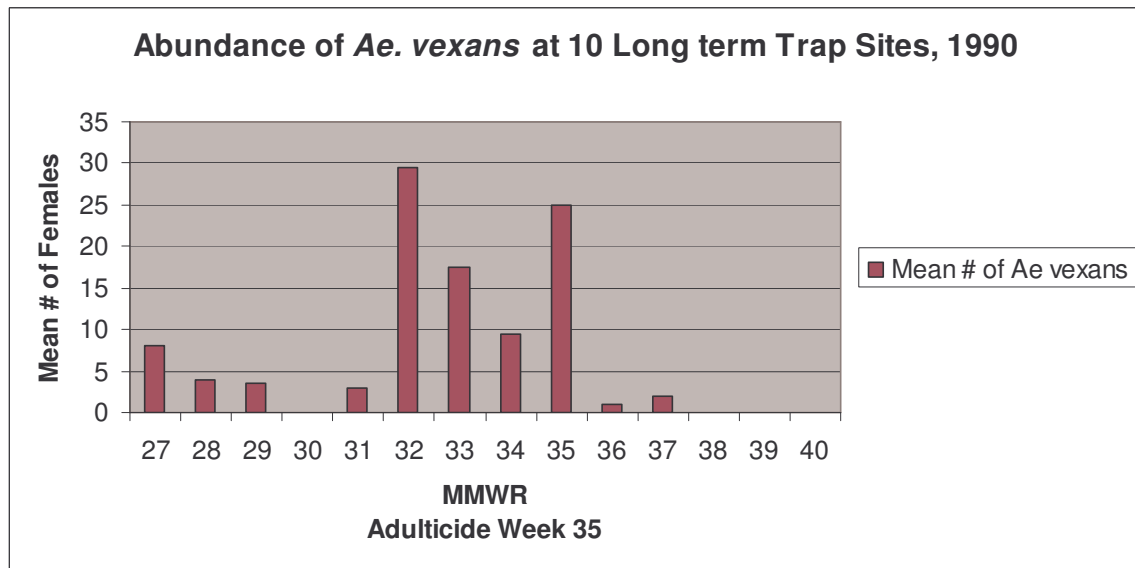
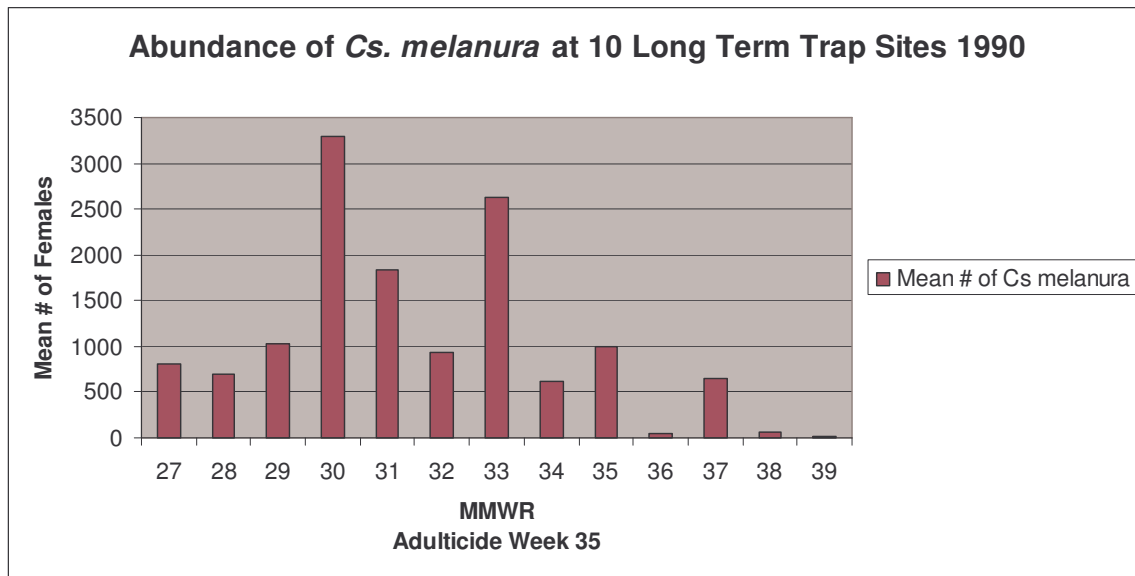
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1990 Eastern Equine Encephalitis Intervention Trap Sites within the Intervention Area

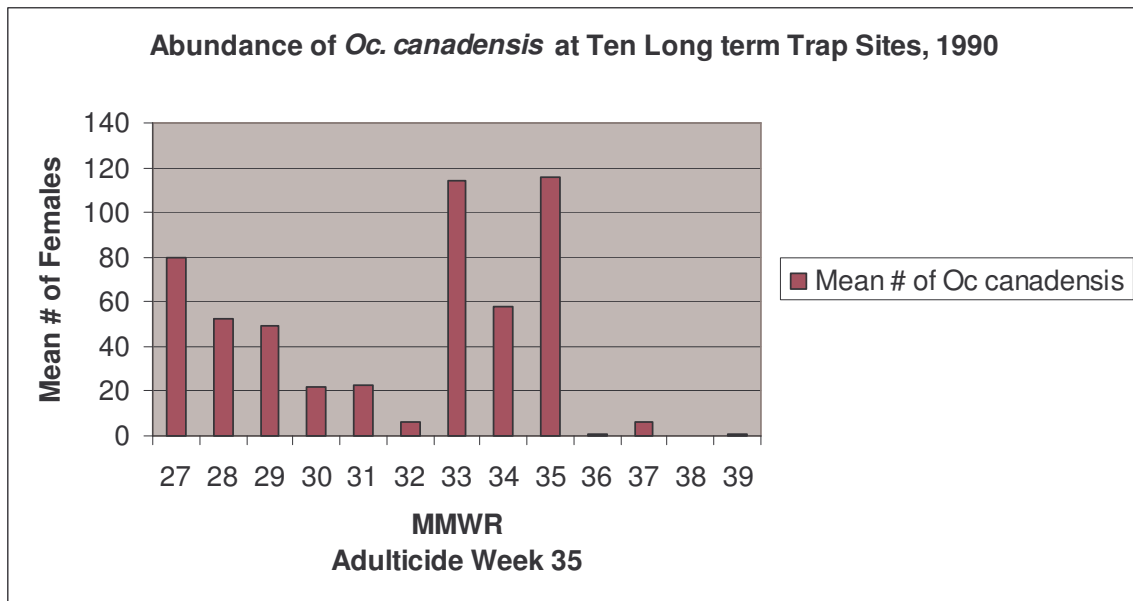
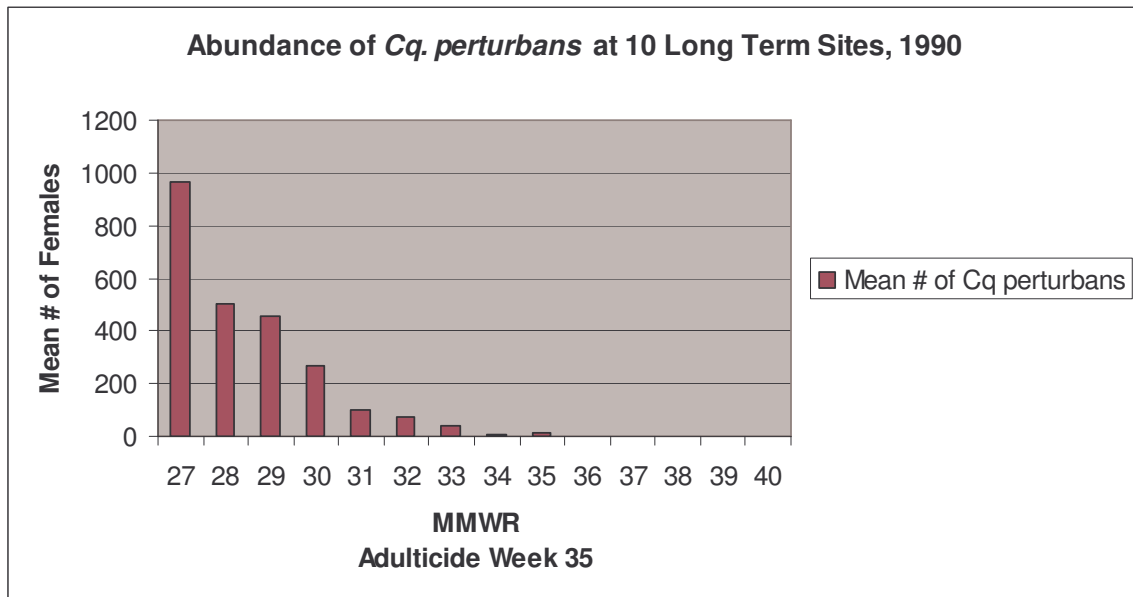
Since 1955 the Massachusetts Department of Public Health has maintained mosquito surveillance sites throughout Massachusetts. These sites have supplied information on virus levels, species and population dynamics. These data were used to evaluate the efficacy of the 1990 Massachusetts EEE Aerial Spray Intervention. Comparing week 35 (pre-spray) to week 36 (post-spray) there was a reduction of 96.1% in total mosquitoes collected from the 10 long term sites in Southeastern Massachusetts within the intervention area.



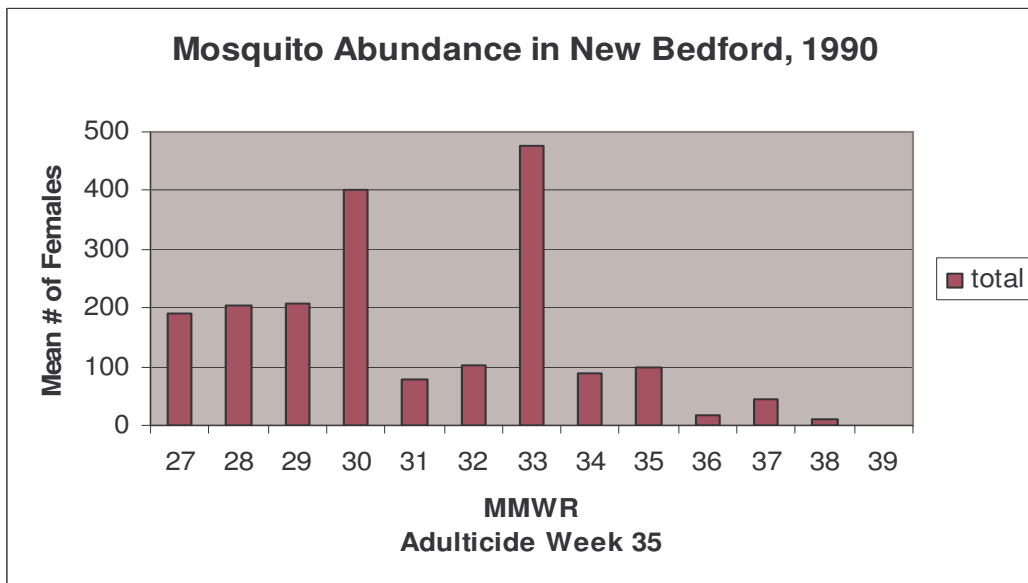
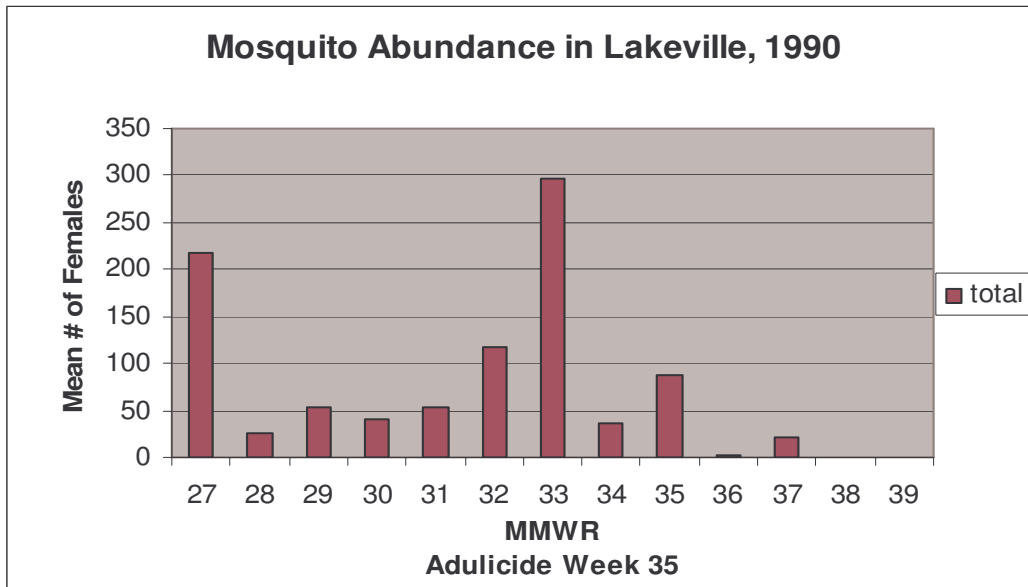
Abundance by Species



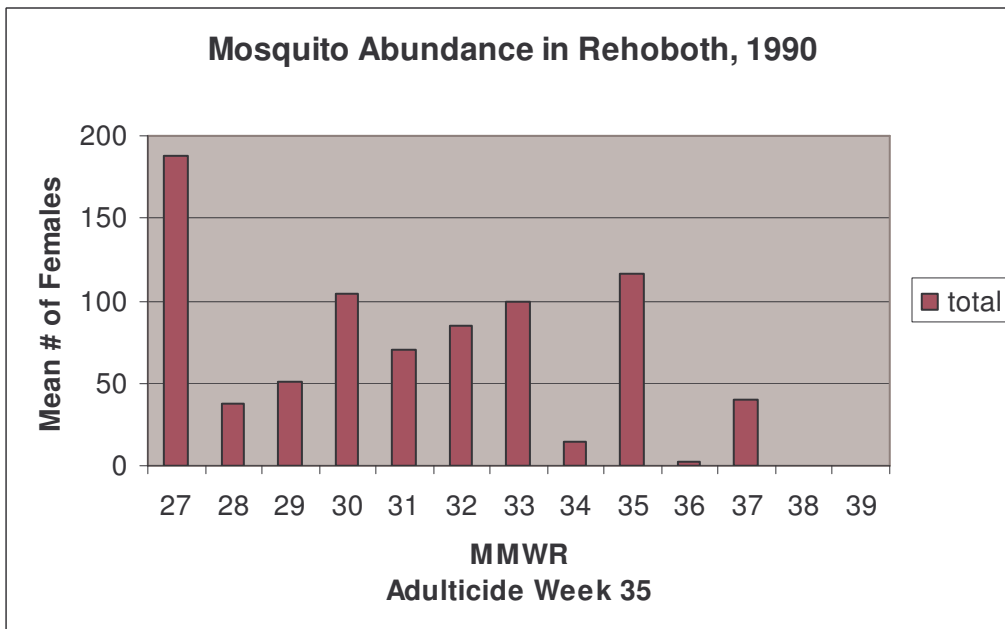
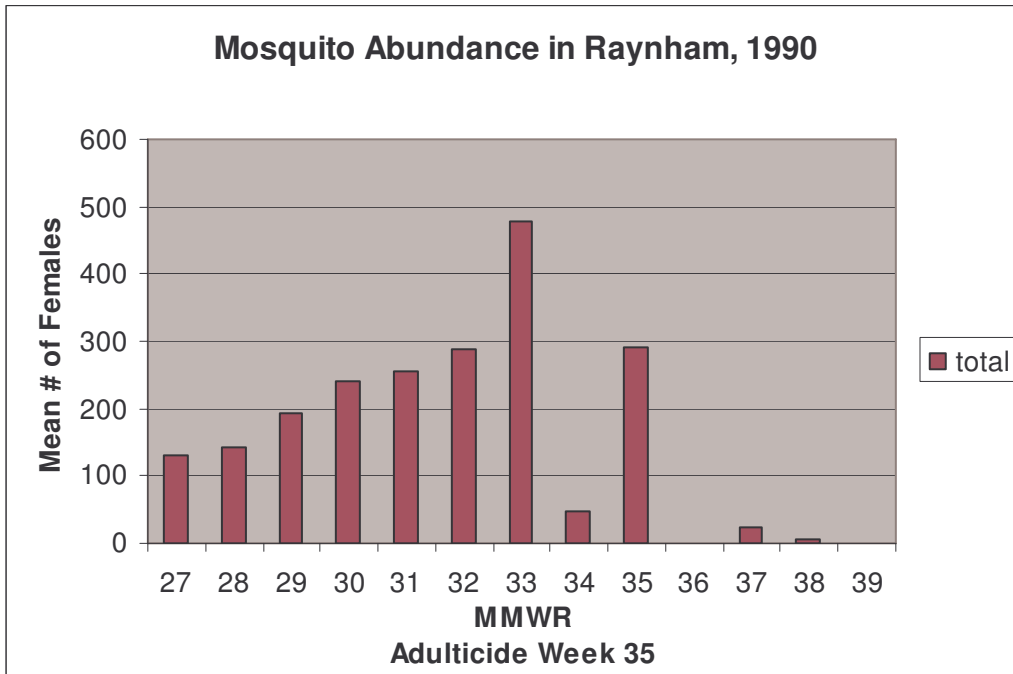
Abundance by Species (continued)



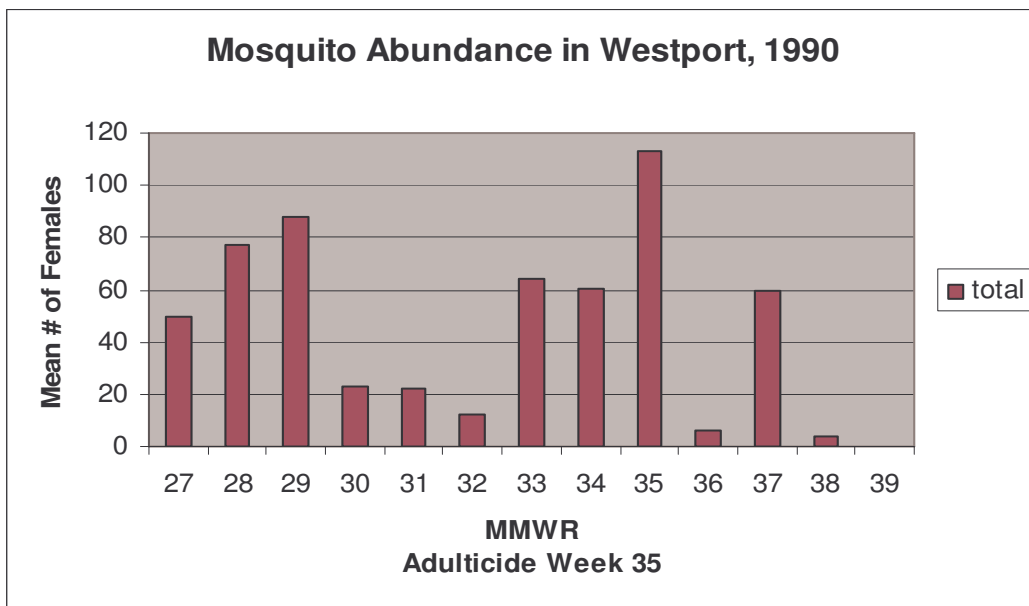
Abundance by Town



Abundance by Town (continued)

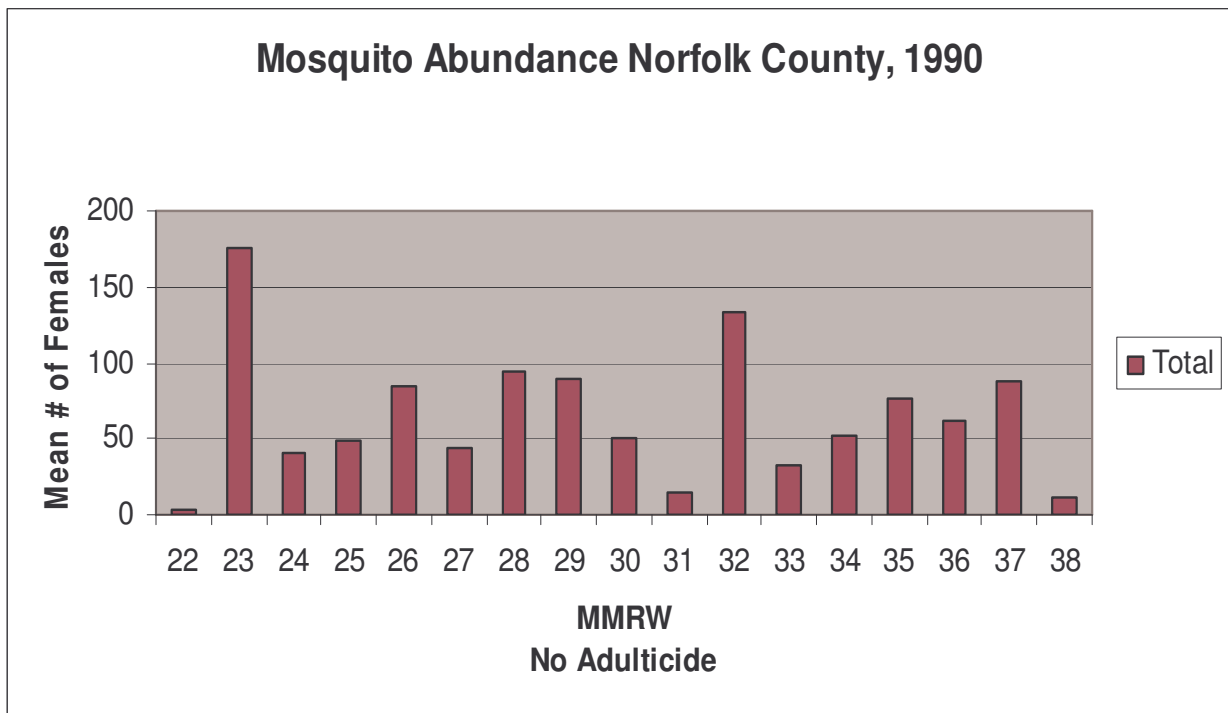


Abundance by Town (continued)



1990 Eastern Equine Encephalitis Intervention Trap Sites Outside the Intervention Area

Since the 1980 the Norfolk County Mosquito Control Project has maintained mosquito surveillance sites throughout Norfolk County. These sites have supplied information on virus levels, species and population dynamics. These data were used to evaluate the efficacy of the 1990 Massachusetts EEE Aerial Spray Intervention. Comparing week 35 (pre-spray) to week 36 (post-spray) there was a reduction of 18.6% in total mosquitoes collected from five sites outside the intervention area.



FIGURES:

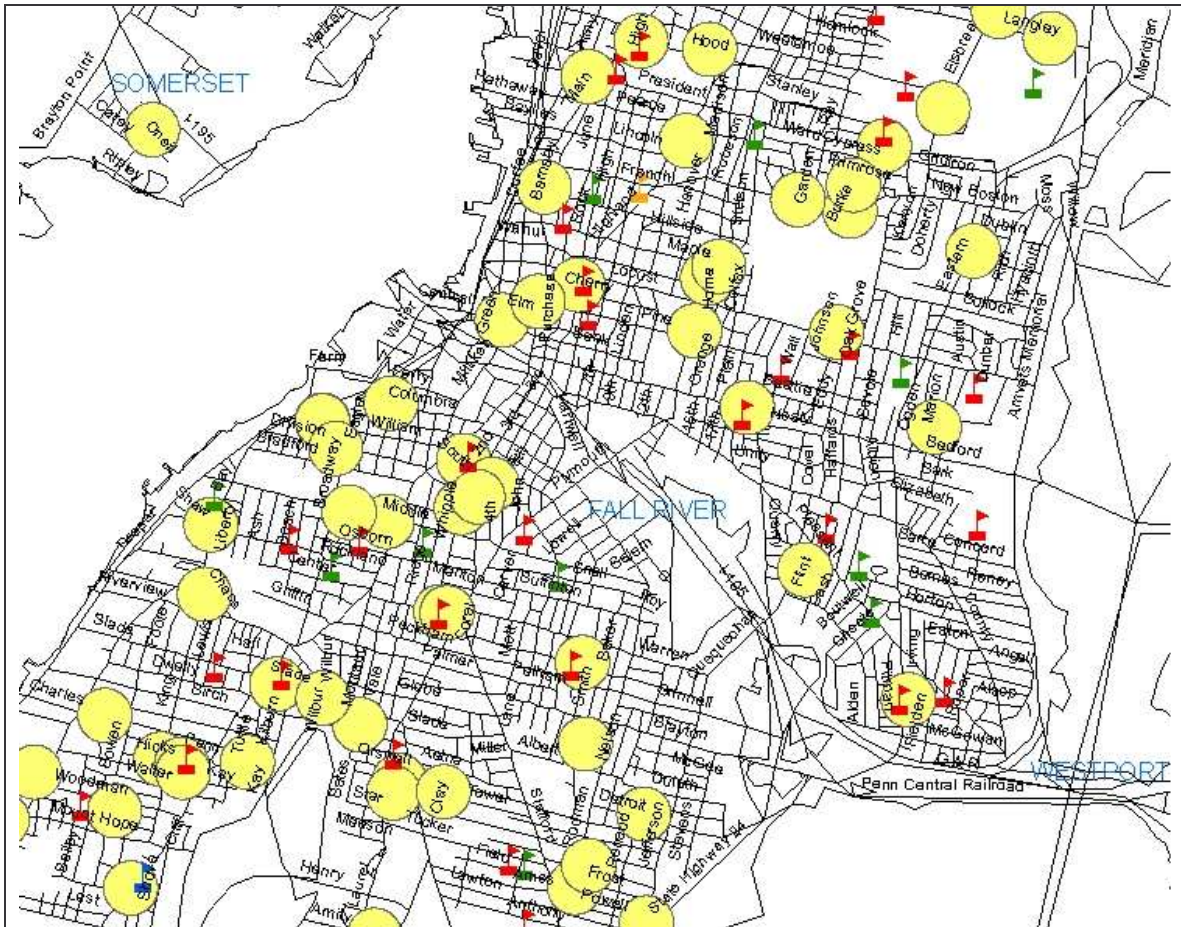


Figure 1. City of Fall River with school and day cares represented by flags and circles respectively. The flags represent a point at the school and does not contain all property owned or operated by the school. These areas are “spray restricted” under the Children’s and Families’ Protection Act.

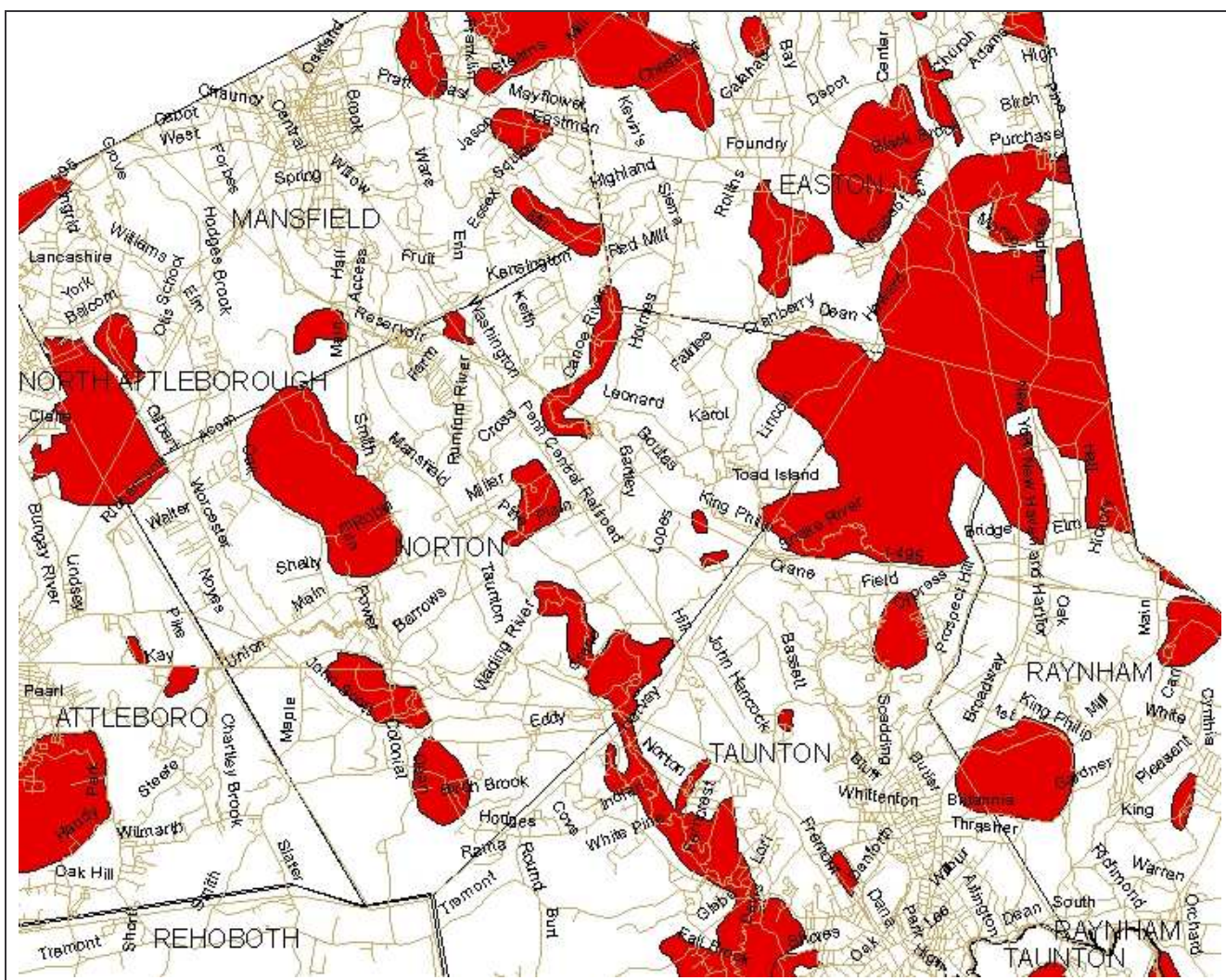


Figure 2. The red areas represent “NHESP 2003 Priority Habitats of State-Listed Rare Species” within Bristol County. The priority habitat has no buffer zone around the area. These areas are “spray restricted” under the Massachusetts Environmental Protection Act.

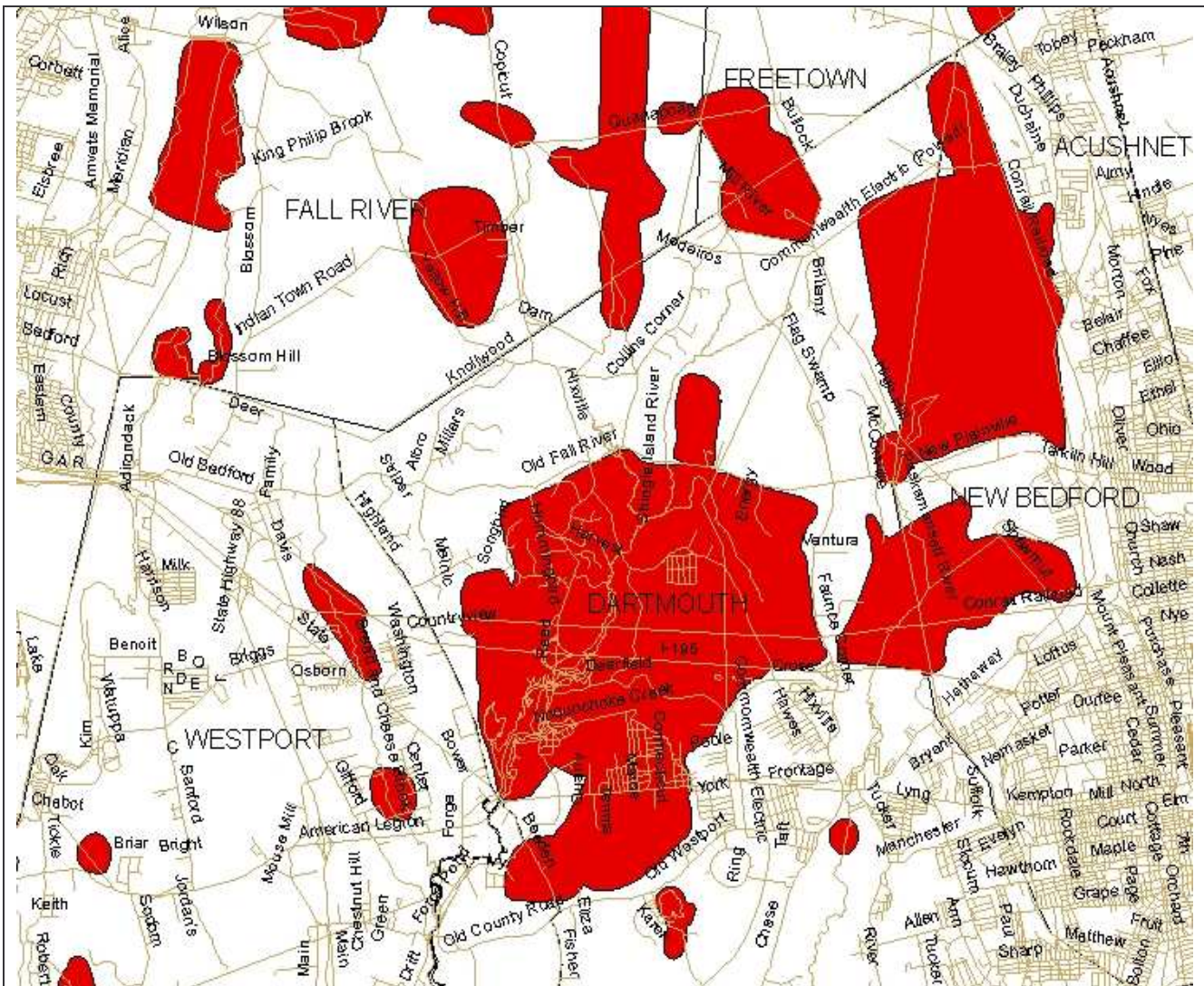


Figure 3. The red areas represent "NHESP 2003 Priority Habitats of State-Listed Rare Species" within Bristol County. The priority habitat has no buffer zone around the area. The priority habitat has no buffer zone around the area. These areas are "spray restricted" under the Massachusetts Environmental Protection Act.